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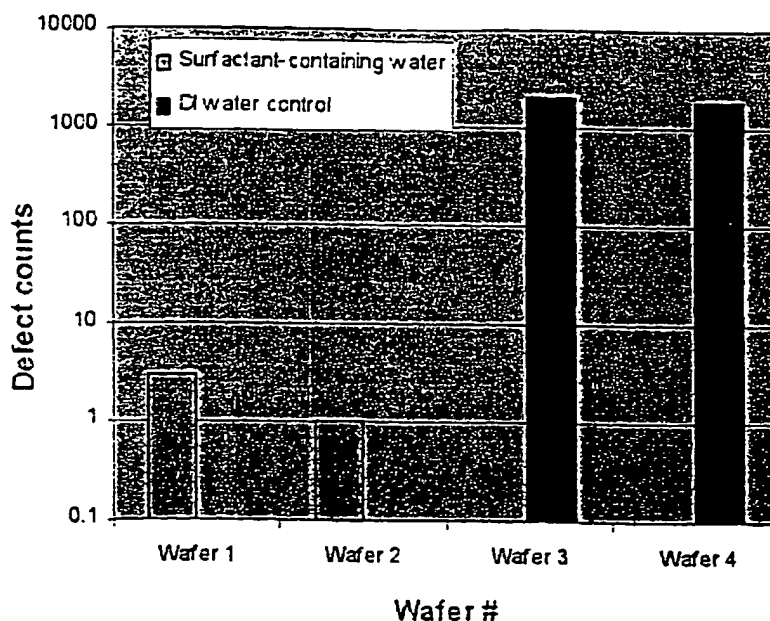
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For two-letter codes and other abbreviations, refer to the "Guid-
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ning of each regular issue of the PCT Gazette.

(54) Title: A METHOD TO REDUCE POST-DEVELOPMENT DEFECTS WITHOUT SACRIFICING THROUGHPUT



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(57) Abstract: Post-development defects in the manufacture of semiconductor devices through the use of surfactants incorporated in the rinse water or the developer for the resist. The surfactants effectively remove resist defects in or around the resist pattern without attacking the resist itself.

A METHOD TO REDUCE POST-DEVELOPMENT DEFECTS WITHOUT SACRIFICING THROUGHPUT

DESCRIPTION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to the manufacture of semiconductor devices and, more particularly, to a method to reduce post-development defects in semiconductor devices without sacrificing throughput.

Background Description

As the minimum feature size of semiconductor devices becomes smaller and smaller, defect control becomes more and more important and challenging particularly for achieving a high product yield. Starting from the qualification of 256M DRAM (Dynamic Random Access Memory) technology, a class of special defects so called "Blob Defects" was discovered on a nested contact hole level of bit line contact CB when using chrome on glass and JSR M20G resist. Later on, it was found that blob defects exist in almost all DUV resist, such as Shipley UV2HS, UV6HS and JSR M60G, regardless of whether it is ESCAP resists or Acetal resists. Actually, the better the resist contrast and surface inhibition is, usually the higher the blob density is. Therefore, selection of contact hole resists for patterning even smaller contact hole size has to face a compromise between defect density and resist lithographic performance, which is not compatible with the trend of low k1 printing. Moreover, no resist evaluated so far shows zero blob density. Blob defects become a limiting factor in resist selection and yield enhancement.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to minimize or eliminate post-development defects.

It is another object of the invention to improve product yield by preventing missing patterns caused by defects.

It is also an object to minimize pattern collapse.

According to the invention, surfactants are incorporated into rinse water or the resist developer. The surfactants effectively remove resist defects in or around the resist pattern without attacking resist itself.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

Figure 1 is a scanning electron microscope (SEM) microphotograph showing a blob defect; and

Figure 2 is a graph showing the effect of surfactant-containing water on defect removal.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now to the drawings, and more particularly to Figure 1, there is shown the morphology of a typical blob defect. This type of defect potentially limits feature size of semiconductor devices and reduces product yield.

The invention incorporates suitable surfactants into rinse de-ionized

(DI) water for defect removal. The surfactant containing DI water would be applied to the resist after patterning and development of the resist. The concentration of surfactants can range from 0.001 to 10%. In a preferred embodiment, the surfactant used was ammonium lauryl sulfate in a concentration ranging from 0.01% to 1%. However, any surfactants with a similar hydrophilic-lipophilic balance (HLB) to ammonium lauryl sulfate will work in removing defects. The surfactant-containing water rinse can be conducted in either a dynamic way (streamline) or a static way (puddle rinse). The time of application can vary from a few seconds to hundreds of seconds. The temperature range can vary from 10°C to 100°C. The surfactants can also be incorporated directly into the developer for defect removal.

Figure 2 shows the effect of surfactant-containing water on defect removal. The resist used in these experiments were Shipley UV83 530nm plus Shipley ARC AR3 90nm. Wafers 1 and 2 were rinsed with surfactant containing de-ionized water, while wafers 3 and 4 were rinsed with de-ionized water without surfactants. Under the exactly same process conditions, the use of surfactant-containing rinse water leads to three orders of magnitude of defect reduction compared to that of pure DI water rinse.

While the invention has been described in terms of a single preferred embodiment, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

CLAIMS

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method to reduce post-development defects in the manufacture of semiconductor devices comprising the steps of:
incorporating suitable surfactants into one of de-ionized rinse water and resist developer; and
applying the surfactant containing de-ionized rinse water or resist developer to a patterned resist on a semiconductor substrate.
2. A method as in claim 1, wherein said surfactants have a concentration ranging from 0.001 to 10%.
3. A method as in claim 1, wherein the surfactant is ammonium lauryl sulfate.
4. A method as in claim 3, wherein the ammonium lauryl sulfate has a concentration ranging from 0.01 to 1%.
5. A method as in claim 1, wherein said surfactants are incorporated directly into said resist developer.
6. A method as in claim 1, wherein said surfactants are incorporated into said de-ionized rinse water used in a dynamic rinse process.
7. A method as in claim 1, wherein said surfactants are incorporated into said de-ionized rinse water used in a static rinse process.
8. A method as in claim 1, wherein said surfactants are incorporated into said

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de-ionized rinse water used in a rinse process lasting between 1 and 1000 seconds.

9. A method as in claim 6, wherein the temperature of said surfactants containing rinse water ranges from 10°C-100°C.

10. A method as in claim 9, wherein the surfactant is ammonium lauryl sulfate.

11. A method as in claim 10, wherein the ammonium lauryl sulfate has a concentration ranging from 0.01 to 1%.

12. A resist developer used or developing resists used in semiconductor manufacture, said resist developer containing a surfactant.

13. The resist developer as in claim 12, wherein the surfactant is ammonium lauryl sulfate.

14. The resist developer as in claim 13, wherein the ammonium lauryl sulfate has a concentration ranging from 0.01 to 1%.

15. A rinse for rinsing developed resists used in semiconductor manufacturer comprising de-ionized water and a surfactant.

16. The rinse as in claim 15, wherein the surfactant is ammonium lauryl sulfate.

17. The rinse as in claim 16, wherein the ammonium lauryl sulfate has a concentration ranging from 0.01 to 1%.

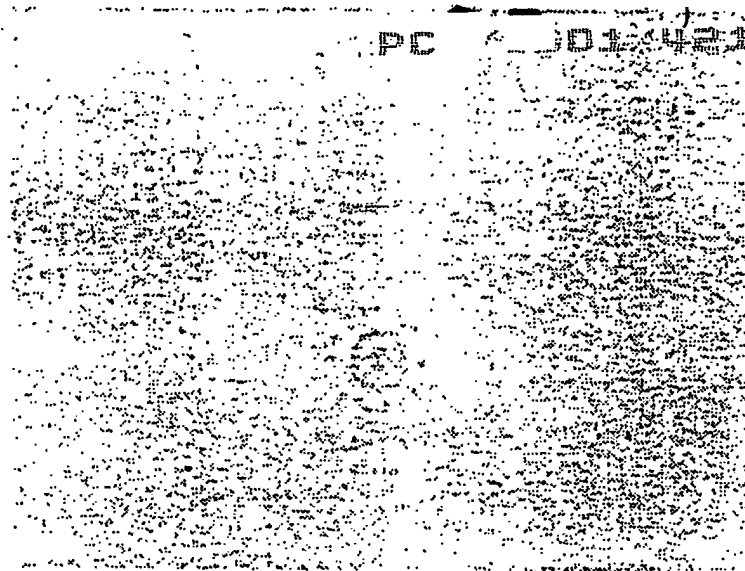


FIG. 1

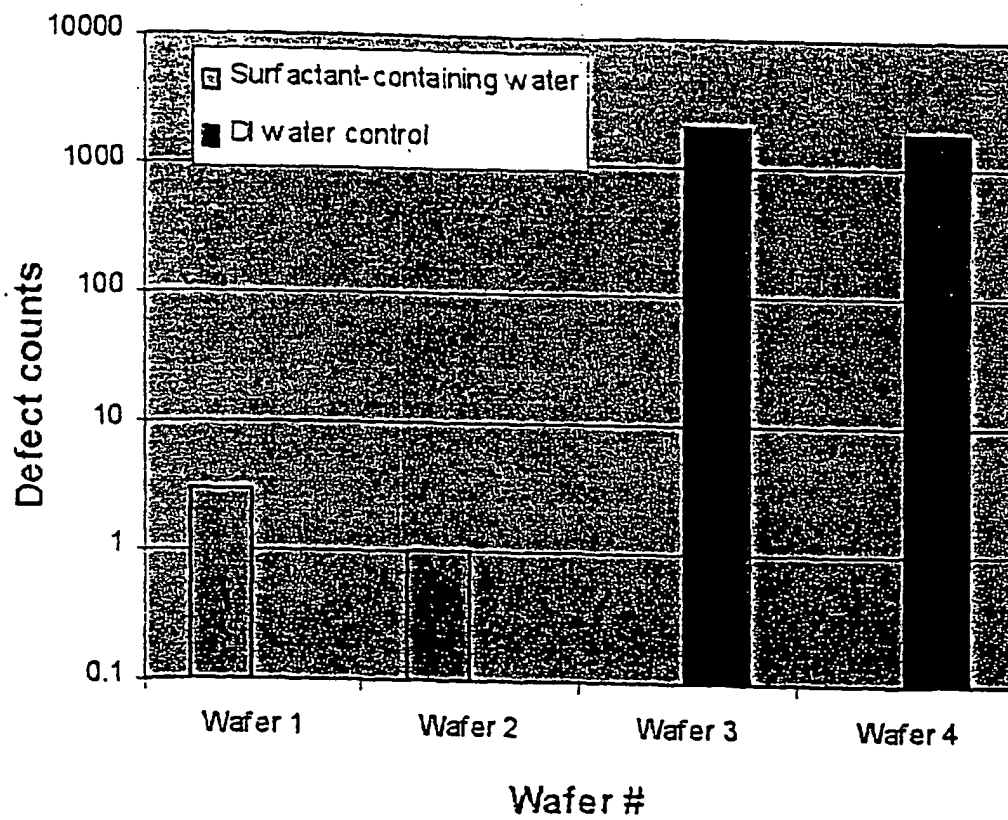


FIG. 2

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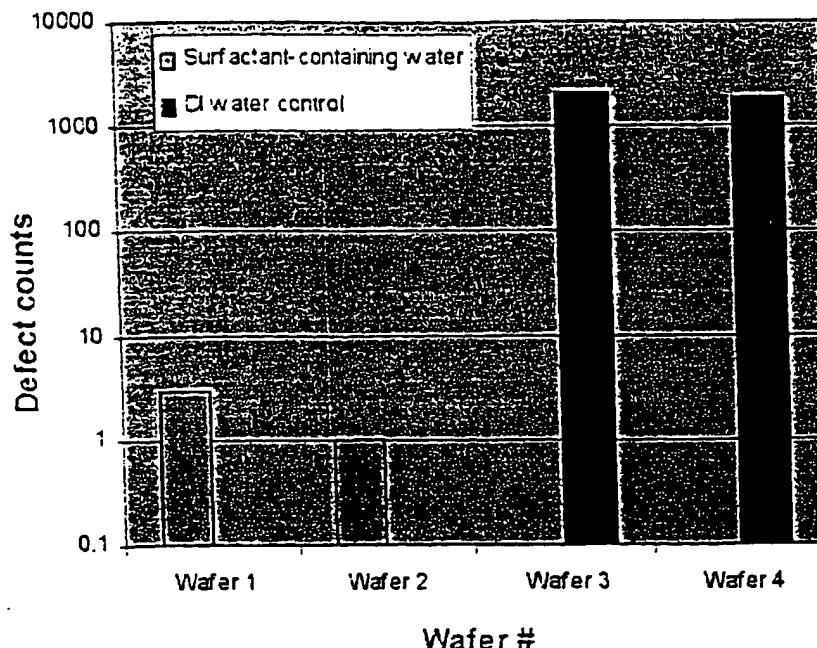
(71) Applicants: **INFINEON TECHNOLOGIES NORTH AMERICA CORP.** [US/US]; 1730 North First Street, San Jose, CA 95112-4508 (US). **INTERNATIONAL BUSINESS MACHINES CORPORATION** [US/US]; New Orchard Road, Armonk, NY 10504 (US).

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 852 743 B (CLARIANT INT LTD) 17 January 1999 (1999-01-17) claims; examples ---	1-3,12, 13,15-17
X	US 5 741 628 A (ENDO MASAYUKI ET AL) 21 April 1998 (1998-04-21) column 15, line 30 - line 46 column 16, line 55 -column 17, line 10 ---	1-4,9,15
X	US 5 286 606 A (RAHMAN M DALIL ET AL) 15 February 1994 (1994-02-15) claims; examples ---	1,12
X	WO 99 53381 A (ETEC SYSTEMS INC) 21 October 1999 (1999-10-21) claims --- -/--	1,12

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 543 268 A (KOMANO HIROSHI ET AL) 6 August 1996 (1996-08-06) claims; examples ---	1,12
X	US 5 164 286 A (BLAKENEY ANDREW J ET AL) 17 November 1992 (1992-11-17) claims ---	1,12
X	US 5 731 132 A (ELTGEN MARLIES ET AL) 24 March 1998 (1998-03-24) column 2, line 23 - line 28; claims; examples ---	1,12
X	US 4 824 769 A (LEWIS JAMES M ET AL) 25 April 1989 (1989-04-25) claims; examples ---	1,12
X	US 4 613 561 A (LEWIS JAMES M) 23 September 1986 (1986-09-23) claims; examples ---	1,12
X	US 5 977 041 A (HONDA KENJI) 2 November 1999 (1999-11-02) claims; examples ---	15
P,X	US 6 136 514 A (PHAN KHOI A ET AL) 24 October 2000 (2000-10-24) column 4, line 1-64; claims ---	1,15-17
P,X	WO 01 63365 A (SHIPLEY CO LLC) 30 August 2001 (2001-08-30) claims; examples -----	1,12,15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 01/42148

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0852743	B	15-07-1998	US 5750031 A DE 69605207 D1 DE 69605207 T2 EP 0852743 A1 JP 11512845 T CN 1196806 A WO 9712281 A1	12-05-1998 23-12-1999 13-07-2000 15-07-1998 02-11-1999 21-10-1998 03-04-1997
US 5741628	A	21-04-1998	EP 0691674 A2 EP 0883163 A2 JP 9230606 A JP 2656913 B2 JP 8076385 A KR 174316 B1 US 5658711 A US 5679500 A	10-01-1996 09-12-1998 05-09-1997 24-09-1997 22-03-1996 01-04-1999 19-08-1997 21-10-1997
US 5286606	A	15-02-1994	DE 69308326 D1 DE 69308326 T2 EP 0677183 A1 HK 70897 A JP 8505241 T SG 47545 A1 WO 9415262 A1	03-04-1997 15-01-1998 18-10-1995 06-06-1997 04-06-1996 17-04-1998 07-07-1994
WO 9953381	A	21-10-1999	AU 3386599 A EP 0991983 A1 WO 9953381 A1 US 6107009 A US 6200736 B1	01-11-1999 12-04-2000 21-10-1999 22-08-2000 13-03-2001
US 5543268	A	06-08-1996	US 6329126 B1	11-12-2001
US 5164286	A	17-11-1992	NONE	
US 5731132	A	24-03-1998	DE 4419166 A1 CN 1117599 A DE 59508636 D1 EP 0685767 A1 JP 7333863 A SG 34226 A1	07-12-1995 28-02-1996 21-09-2000 06-12-1995 22-12-1995 06-12-1996
US 4824769	A	25-04-1989	US 4670372 A CA 1265373 A1 DE 3580443 D1 EP 0178496 A2 JP 1851404 C JP 5062984 B JP 61097652 A KR 8900803 B1	02-06-1987 06-02-1990 13-12-1990 23-04-1986 21-06-1994 09-09-1993 16-05-1986 07-04-1989
US 4613561	A	23-09-1986	CA 1261194 A1 CN 85107347 A DE 3576742 D1 EP 0178495 A2 JP 1863222 C JP 5073227 B JP 61097653 A	26-09-1989 20-08-1986 26-04-1990 23-04-1986 08-08-1994 13-10-1993 16-05-1986

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 01/42148

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4613561	A		KR 8900804 B1	07-04-1989
US 5977041	A	02-11-1999	AU 9497398 A	12-04-1999
			EP 1017770 A1	12-07-2000
			JP 2001517728 T	09-10-2001
			WO 9915609 A1	01-04-1999
US 6136514	A	24-10-2000	US 6251570 B1	26-06-2001
WO 0163365	A	30-08-2001	AU 3869601 A	03-09-2001
			WO 0163365 A1	30-08-2001
			US 2002001780 A1	03-01-2002